REPORT

Investigating Impacts of Wind Power Development in the M-KMA – An Evaluation of Current Wind Power Tenures within the M-KMA

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ABSTRACT

Wind energy is an alternative and renewable energy resource with few of the greenhouse gas impacts associated with hydro-carbons; however the rapid growth in the wind energy industry has met with controversy and concerns. Impacts to wildlife, wildlife habitat, ecosystem function, and societal values (e.g., perceptions of wilderness) have recently emerged. The significance of many known impacts remains unclear. Much of the current uncertainty can be traced to insufficient regulatory oversight, a rapid growth of the industry that has resulted in more wind energy facilities and an ever widening geographic footprint, rapidly evolving wind turbine technology, and a lack of rigorous and objective research to quantify impacts and place them in a meaningful perspective.

Wind power facilities are being built in new ecological settings such as high-elevation alpine habitat, often without appropriate or relevant guidance. Unanticipated impacts have, and are occurring. Impacts can be categorized into two broad categories: direct impacts (fatalities to wildlife) and indirect impacts (functional and structural changes in ecosystems). Impacts, however, are not simply measured in terms of wildlife and habitat, but also in terms of people's perceptions, although these may be easier to quantify.

The Muskwa-Kechika Management Area (M-KMA) is faced with a novel situation as high elevation subalpine and alpine ridge lines that provide important seasonal habitat for large mammals (e.g., caribou and grizzly bears) and avian migrators are the primary sites proposed for wind energy development. These appear to be the first developments within these habitat types and within a regional context of relatively pristine ecosystems. In addition to ecological impacts, ridgeline developments have a high potential to impact visual landscapes over vast areas.

We evaluated the anticipated impacts of three current wind power tenures (IUP) within the M-KMA with respect to wildlife, wildlife habitat, and wilderness values. IUP footprints plus 100m buffers had no table effects on focal wildlife habitat that ranged from 2,538 ha for sheep habitat to 10,537 ha for caribou habitat. IUPs were almost entirely situated within the front ranges and summed over all three IUPs, 99.3% of footprints and buffered footprints totalling 4,377 ha and 15,768 ha respectively, were within the front ranges. Protected areas also experienced effects from IUP footprints (2,862 ha) and IUP buffered footprints (9,929 ha). Across all three IUPs, 1,105 km of linear disturbance, composed of 490 km of access roads, 591 km of power transmission rights-of-way, and 25.9 km of backbone roads were estimated to be required to support the operational phase of the wind power installations. With respect to wilderness areas within the M-KMA, approximately 450,670 ha (8.6% of total wilderness) were affected by the IUP viewshed. For the front ranges we estimated that 202,798 ha (17%) were affected by the viewshed. We used a modified 'wildlife viewshed' analysis to illuminate potential disturbance or avoidance effects of wind towers on focal wildlife species and estimated that 35,391 ha (0.7%) of habitat for caribou, moose, and sheep overall, 29,347 ha (0.9%) of caribou habitat, 20,225 ha (0.9%) of moose habitat, and 5,660 ha (0.4%) of sheep habitat were affected.

Our analyses of IUP buffered footprints suggest that habitat disturbance will likely exceed prescribed targets for all three focal species in the Upper Halfway River Watershed. Analyses of wildlife viewsheds also suggest that targets for undisturbed

wildlife habitat over the four affected watersheds will not be met. We conclude that wind power developments will have long-term (>100 years) implications on habitat suitability and possibly the status of some wildlife species, in part due to the indefinite lifespan of wind power projects but also due to the slow recovery of alpine habitats following disturbance. Additionally, the ability of the Muskwa-Kechika Advisory Board to respond to declines in wildlife populations, or to mitigate climate change that is expected to reduce the extent of alpine habitats, will likely be impaired.

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INTRODUCTION

The Muskwa-Kechika Management Area (M-KMA) was established with the goal of ensuring the maintenance of wildlife, wilderness, and cultural values in perpetuity while allowing for resource development. It is stipulated in the Muskaw-Kechika Management Plan Regulation1[1] that strategic plans are required for oil and gas, forestry, wildlife, parks and recreation. As a new resource development activity, wind power does not fall under the auspices of the Regulation and no strategic plan is currently required.

Although some strategic plans are yet to be completed (i.e., parks and recreation), general management themes include minimizing ecological footprints, blending anthropogenic activities into the visual landscape, and timely reclamation of disturbances back to pre-existing wilderness characteristics (restoration of pre-existing flora, fauna and visual landscape) (M-KAB 2004). Within parks, wilderness will remain unaffected by industrial activities.

The objectives of this evaluation are to assess the three wind power tenures (IUPs) that exist within the M-KMA insofar as their comparability and compatibility with other specific values of the area including:

- wildlife;
- wildlife habitat; and
- wilderness.

Wildlife values (and by extension, wildlife habitat values) are embodied in the abundance and diversity of wildlife and within M-KMA's definitions of 'ecological system' and 'ecological integrity' (M-KAB 2004) that advocate viable, self-sustaining plant and wildlife populations that are unimpaired by anthropogenic disturbances and that function within the range of natural variation. Wilderness values extend the concepts of ecological systems and integrity to a large area (>5,000 ha) perceived by humans to be natural due to an absence of detectable post-European-contact human activities.

STUDY AREA

The M-KMA is located in north-eastern BC, its' extent ranging approximately from N56^{o}22' to N59^{o}57' and W122^{o}47' to W128^{o}56'. The M-KMA is comprised of four biogeoclimatic zones, Boreal Black and White Spruce (BWBS), Spruce Willow Birch (SWB), Boreal Altai Fescue Alpine (BAFA) and Engelmann Spruce – Subalpine Fir (ESSF) (Figure 1). The BWBS zone forms nearly a quarter of the M-KMA, dominating the plateau areas in the north east and the valley bottoms of rugged mountainous terrain. The two main ecosystems found in the BWBS are upland forests and muskeg. Stands of trembling aspen (*Populus tremuloides*), balsam poplar (*P. balsamifera*), white spruce (*Picea glauca*), lodgepole pine (*Pinus contorta*), and black spruce (*P. mariana*) can be found in the upland forests, occupying suitable sites dependent on drainage and

[1] http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/10_53_2002.

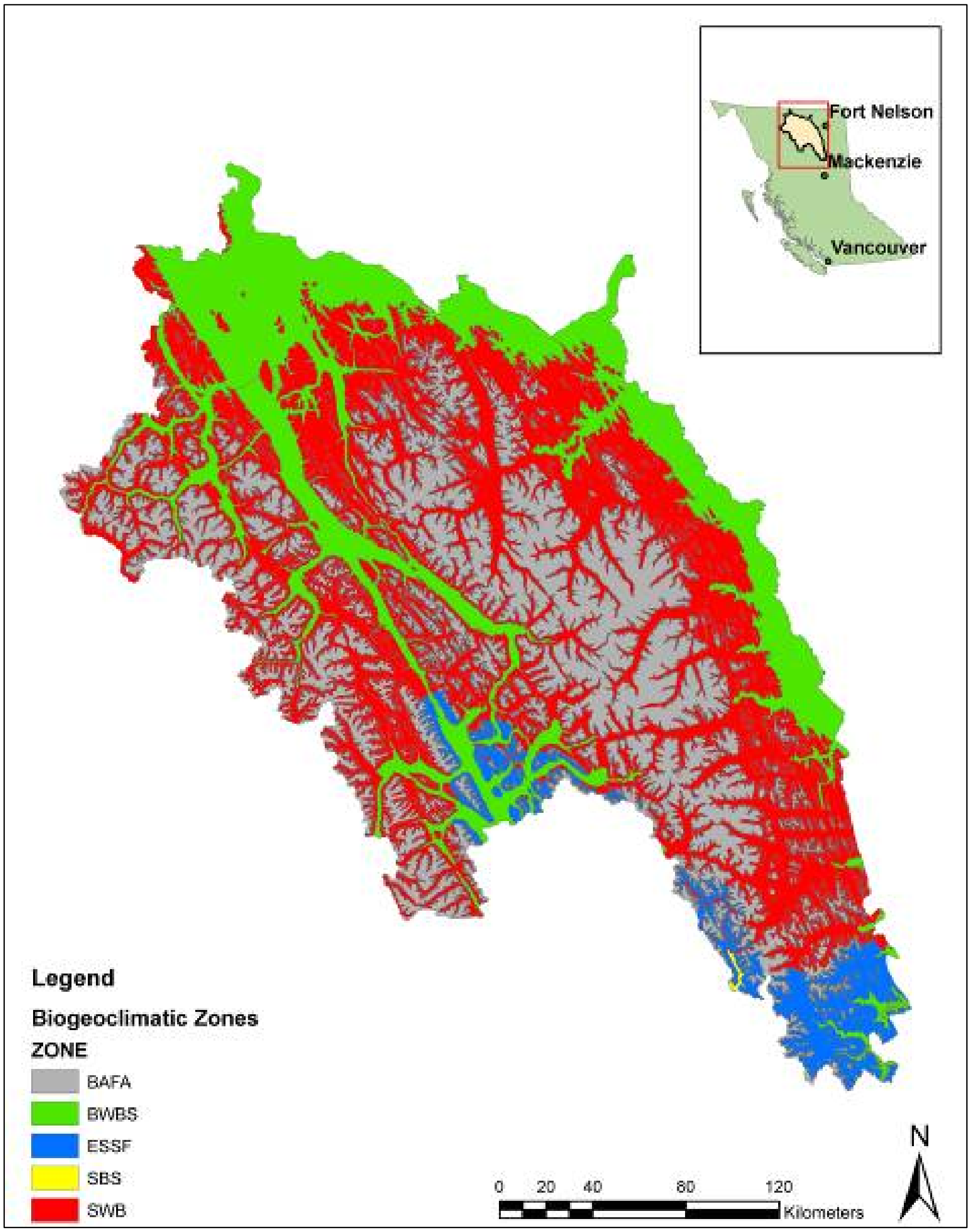

Figure 1. The biogeoclimatic zones represented in the Muskwa-Kechika Management Area in northern British Columbia.

topography. The muskeg ecosystem supports both black spruce and tamarack (*Larix laricina*) tree species and is primarily a result of a climate which is both long and cold in the winter and warm and short in the summer with the presence of permafrost. Precipitation in the BWBS is relatively low and it receives the least amount of snowfall of the four zones found in the M-KMA. Long cold winters and short cool summers are characteristic of the SWB zone which generally has a harsh climate. This zone is dominant covering nearly half of the M-KMA and occurs between the BWBS and Alpine Tundra zones. Tree species are more limited than the BWBS zone; white spruce, trembling aspen and lodgepole pine can be found at the lower elevations of the SWB shifting to more dominant stands of subalpine fir (*Abies lasiocarpa*) to deciduous shrubs at higher elevations. Many of these forests are relatively old due to infrequent fires; although, large burns have been introduced to create open grassland areas with occurrences of trembling aspen.

The BAFA zone occurs on a quarter of the M-KMA landscape. It occurs in the mountainous high elevations in steep rugged terrain. The growing season is relatively short with temperatures rising above 0^{o}C for 1 to 4 months of the year. Ecosystems are a patchy mosaic near the treeline, a combination of krummholz, alpine tundra and alpine meadows. Distribution of plant and tree species is highly dependent on erosion deposition, drainage, precipitation and aspect. The ESSF zone is limited to the southeastern portion of the M-KMA and upper portion of the Fox River drainage. It occurs in mountainous terrain typically at mid slope elevations and high elevation valleys. The climate conditions create long cold winters with deep snow packs and short cool summers. Engelmann spruce (*P. engelmannii*) and subalpine fir are the main tree species in the ESSF. Pure stands of subalpine fir occur at higher elevations forming patchy tree islands in the subalpine parklands. There is only a trace occurrence of the Sub-Boreal Spruce zone in the lower southeastern portion of the M-KMA and hence will not be discussed.

The M-KMA is occupied, or partially occupied, by eight herds of woodland caribou (*Rangifer tarandus*) (i.e., the Rabbit, Muskwa, Pink Mountain, Gataga, Frog, Horseranch, Finlay, and Graham herds). These are herds of woodland caribou that are considered by the Council on the Status of Endangered Wildlife in Canada (Thomas and Gray 2002) to be a species-at-risk and, for the most part, are listed as “special management concern”; the Graham herd has been listed as “threatened”. Other significant wildlife species include black bears (*Ursus americanus*), grizzly bears (*Ursus arctos*), wolves (*Canis lupus*), moose (*Alces americanus*), mountain goats (*Oreamnos americanus*), elk (*Cervus canadensis*), plains bison (*Bos bison bison*), wood bison (*Bos bison athabascae*), mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), wolverines (*Gulo gulo*) and Stone’s sheep (*Ovis dalli stonei*).

METHODS

We used the results of a physical feasibility model (Snively and Brumovsky 2011) to conduct a series of spatial analyses (McCann and Snively 2011) that characterized the area of the M-KMA potentially influenced by development of three existing IUPs within the M-KMA. The area influenced was stratified by:

- watersheds[2];
- wilderness (areas outside of existing disturbances buffered by 3.83 km),

[2] WSA – BC Watershed Groups (1:50k) available from Geographic Data Discovery Service (https://apps.gov.bc.ca/pub/geometadata/home.do).

- wildlife habitat (caribou, moose, sheep)[3];
- protected areas (parks, proposed and approved Ungulate Winter Range, and proposed and approved Wildlife Habitat Areas)[4]; and
- Ecosections (Muskwa Foothills and Peace Foothills)[5].

For watersheds with IUPs within them we determined the total area and the wilderness area affected by IUP footprints (tower pads, power transmission right-of-way, and roads; see Snively and Brumovsky 2011) and by IUP footprints buffered by 100m. Wildlife habitat analyses for focal species (caribou, moose, and sheep) were similarly focused on calculations of the habitat area, by watershed, affected by IUP footprints and footprints plus the buffer.

Protected area analyses were used to examine the effect of IUP footprints and footprints buffered by 100m on a merged spatial layer of parks, Ungulate Winter Ranges and Wildlife Habitat Areas. In the analysis of Ecosections, we examined the effect of IUP footprints and footprints buffered by 100m on the front ranges of the M-KMA (Muskwa and Peace Foothills) that provide important winter habitat for several ungulate species.

We conducted two types of viewshed analyses for the M-KMA: 1) a worst-case, wilderness oriented scenario that incorporated all wind towers (IUPs and potential wind power development sites) in the M-KMA and within a 15-km buffer about the M-KMA (some wind towers in the buffer were visible within the M-KMA) with no restrictions on how far away the visible wind towers were; and 2) a wildlife viewshed that used the same suite of wind towers as the worst-case scenario, but limited the viewshed to visible wind towers within 1 km. Both viewshed analyses did not permit resolving the influence of wind towers belonging only to IUPs and our assessment of viewsheds stemming from IUPs was generalized.

We estimated an overall area, wilderness area, and front ranges area affected by the worst-case, wind tower viewshed (see Snively and Brumovsky 2011) adjusted for the contribution of towers only from IUPs. We also examined the adjusted effects of the hypothetical wildlife viewshed on protected areas, the front ranges, and each selected species' habitat. We defined wildlife viewsheds (also see Snively and Brumovsky 2011) as those areas with 1 or more visible wind towers within 1 km under the assumption that visible wind towers close to wildlife habitat could disrupt normal activities such as foraging through perceived noise or motion leading to increased vigilance behaviour or eventual displacement. We did not analyze wildlife viewsheds at the level of watersheds.

We also enumerated linear estimates of access roads and transmission lines required to support the IUPs (Snively and Brumovsky 2011) and estimated the number of wind towers by IUP, categorized into wind towers within the M-KMA and wind towers within a 15-km buffer placed around the M-KMA. Linear access associated with IUPs was

[3] See Snively and Brumovsky (2011)

[4] Wildlife Habitat Areas, Wildlife Habitat Areas – Proposed, Ungulate Winter Ranges, Tantalis – Parks, Ecological Reserves, and Protected Areas, available from Geographic Data Discovery Service (https://apps.gov.bc.ca/pub/geometadata/home.do).

[5] Ecosections – Ecoregion Ecosystem Classification of British Columbia, available from Geographic Data Discovery Service (https://apps.gov.bc.ca/pub/geometadata/home.do).

categorized into three components: the IUP's proportion of low-elevation backbone road following assignment rules developed by Snively and Brumovsky (2011), the IUP's access road from the backbone road to the installation including roads within the installation, and the IUP's power transmission right-of-way.

RESULTS

Three IUPs currently exist in part within the M-KMA: Crown Land #8014827 (hereafter 01_E), Crown Land #8014828 (hereafter 02_E), and Crown Land #8014187 (hereafter 33_E). We summarized the primary effects of IUP footprints and buffered footprints in Table 1 and Table 2.

Table 1. Area (ha) affected by existing IUPs' footprints or buffered footprints, categorized by watershed, wilderness, caribou habitat, moose habitat and sheep habitat.

IUP	WS[1]	FP[2]	FP+100m	FP Wilderness[3]	FP+100m Wilderness	FP Caribou Habitat	FP+100m Caribou Habitat	FP Moose Habitat	FP+100m Moose Habitat	FP Sheep Habitat	FP+100m Sheep Habitat
01_E	UPRO[4]	1,228.5	4,346.7	185.2	669.9	990.3	3490.3	364.6	1,336.8	220.9	973.1
	USIK	567.0	2,051.1	0.0	0.0	509.5	1825.1	145.3	587.9	153.1	707.1
02_E	UHAF	1,854.9	6,673.4	267.7	927.1	945.6	3340.9	1,318.5	4,851.4	95.1	469.6
	USIK	528.6	1,983.4	0.0	0.0	443.2	1612.9	241.4	979.9	83.5	387.9
33_E	LHAF	6.9	12.4	0.0	0.0	2.4	3.4	3.5	7.7	0.0	0.0
	UHAF	222.6	814.2	0.0	0.0	79.9	263.9	173.8	647.2	0.2	0.4
Totals	n/a	**4,408.5**	**15,881.2**	**452.9**	**1,597.0**	**2,970.9**	**10,536.5**	**2,247.1**	**8,410.9**	**552.8**	**2,538.1**

[1] WS = Watershed.
[2] FP = Footprint.
[3] Wilderness = areas not impacted by existing anthropogenic disturbances.
[4] UPRO = Upper Prophet River, USIK = Upper Sikanni Chief River, UHAF = Upper Halfway River, LHAF = Lower Halfway River.

Table 2. Area (ha) affected by existing IUPs' footprints or buffered footprints, for the front ranges (Muskwa and Peace Foothills Ecosections combined) and for protected areas.

IUP	FP Front Ranges[1]	FP+100m Front Ranges	FP Protected Areas[2]	FP+100m Protected Areas
01_E	1,763.66	6,284.34	1,163.86	4,085.22
02_E	2,383.52	8,656.85	1,535.38	5,268.98
33_E	229.51	826.62	162.82	574.83
Totals	**4,376.69**	**15,767.81**	**2,862.06**	**9,929.03**

[1] Muskwa and Peace Foothills combined.
[2] Parks, Ungulate Winter Ranges and Wildlife Habitat Areas.

Each IUP, whether by footprint or buffered footprint, affected two watersheds, and illuminated their positioning on heights on land (Table 1). In total, four watersheds experienced effects from the IUPs': Upper Prophet River (footprints = 1,229 ha, buffered footprints = 4,347 ha), Upper Sikanni Chief River (footprints = 1,096 ha, buffered footprints = 4,035 ha), Upper Halfway River (footprints = 2,078 ha, buffered footprints =

7,488 ha), and Lower Halfway River watersheds (footprints = 6.9 ha, buffered footprints = 12.4 ha).

IUP effects on wilderness areas (Table 1) that lay outside the buffered existing disturbances within the M-KMA were minimal (summed over all three IUPs: 453 ha for footprints; 1,597 ha for buffered footprints) as most of the affected area occurred on land that was already impacted by 1 or more existing disturbances (see McCann and Snively 2011). IUP effects on focal wildlife habitat (Table 1) were more notable, in particular for buffered footprints and ranged from 2,538 ha for sheep habitat to 10,537 ha for caribou habitat. By watershed and focal species, buffered footprints summed across IUPs affected 0.01% (Lower Halfway River) to 3.8% (Upper Halfway River) of caribou habitat, 0.01% (Lower Halfway River) to 3.7% (Upper Halfway River) of moose habitat, and 0% (Lower Halfway River) to 2.7% (Upper Halfway River) of sheep habitat.

IUPs were almost entirely situated within the front ranges (Table 2) and summed over all three IUPs, 99.3% of footprints and buffered footprints totalling 4,377 ha and 15,768 ha respectively, were within the front ranges. Protected areas (Table 2) also experienced notable effects from IUP footprints (2,862 ha) and IUP buffered footprints (9,929 ha).

Estimated number of wind towers by IUP ranged from 161 to 224. Wind towers for IUPs 01_E and 02_E were located primarily within the M-KMA while most wind towers for IUP 33_E were within the 15-km buffer (Table 3). Only IUP 01_E relied on a backbone road within the M-KMA as IUPs 02_E and 33_E used backbone roads within the 15-km buffer surrounding the M-KMA. Across all three IUPs, 1,105 km of linear disturbance, composed of 490 km of access roads, 591 km of power transmission rights-of-way, and 25.9 km of backbone roads were estimated to be required to support the operational phase of the wind power installations.

Table 3. Estimated number of towers by IUP in the M-KMA and 15-km buffer about the M-KMA, and length (km) of IUP linear disturbances (access roads, transmission lines and proportion of backbone road assigned to IUP) within the M-KMA.

IUP	Towers in M-KMA	Towers in Buffer	Total Towers	Access Road (km)	Transmission Line (km)	Backbone Road (km)	Total Linear Disturbance (km)
01_E	210	14	224	199.0	231.6	25.9	456.5
02_E	247	39	286	262.2	330.4	0.0	592.6
33_E	44	117	161	28.5	28.5	0.0	57.0
Totals	**501**	**170**	**671**	**489.7**	**590.5**	**25.9**	**1,106.1**

The 671 wind towers estimated for the three IUPs represented 30% of the 2,238 wind towers used in the viewshed and wildlife viewshed analyses. For the worst case viewshed analysis, a total of 2,173,011 ha of the M-KMA had at least one visible wind tower. We assumed that approximately 30% (651,903 ha) of this area was due to the IUPs. With respect to wilderness areas within the M-KMA, approximately 450,670 ha (8.6% of total wilderness) were affected by the IUP viewshed. For the front ranges we estimated that 202,798 ha (17%) were affected by the viewshed.

Similarly, we assumed that 30% of the wildlife viewshed was attributable to the IUPs with effects on caribou, moose, and sheep habitat as follows: 35,391 ha (0.7%) of habitat for caribou, moose, and sheep overall affected; 29,347 ha (0.9%) of all caribou habitat affected; 20,225 (0.9%) ha of all moose habitat affected; and 5,660 (0.4%) ha of all sheep habitat affected. Sums across individual species exceeded the overall total for focal wildlife habitat due to overlaps in species' habitat (e.g., 1,355,544 ha of the M-KMA were habitat for both caribou and moose). Although wildlife viewsheds were not analyzed at the level of watersheds, it was reasonable to assume that wildlife viewshed effects were limited to the four watersheds affected by footprints and buffered footprints due to the 1 km restriction. The effects of wildlife viewsheds, in comparison to the sum of each focal species' habitat in the four affected watersheds was 5.8% of the 509,054 ha of caribou habitat affected, 4.6% of the 444,434 ha of moose habitat affected, and 3.6% of the 155,654 ha of sheep habitat affected. We also estimated that 24,178 ha (2.0%) of the front ranges and 14,531 ha of protected areas (0.7%) were affected by wildlife viewsheds attributable to the IUPs.

DISCUSSION

Wildlife and Wildlife Habitat

Through the Muskwa-Kechika Wildlife Management Plan (M-KWMP 2009*a*), the Muskwa-Kechika Advisory Board has the broad mandate to maintain "*the abundance and diversity of indigenous wildlife and their habitat in the context of human activities and uses*". This means that, while managing within the range of natural variation, the intent is to support key biological functions such as connectivity, natural habitat fragmentation, and predator-prey dynamics. Goals for priority wildlife species include: 1) allowing populations to naturally fluctuate in size without risk of extirpation during periods of low population sizes; and 2) managing risk from anthropogenic sources to avoid populations reaching low numeric thresholds. A strong emphasis is placed on habitat management at scales ranging from stand level to landscape, and access management to maintain habitat and its functionality through management protocols (M-KWP 2009*b*) such as:

- Maintain important habitat and suitability;
- Maintain large patches and connectivity, minimize fragmentation (caribou);
- Minimize impacts due to access through limiting access at sensitive times (natality areas, winter ranges) and use coordinated planning to minimize cumulative and long-term access effects; and
- Avoid creation of predator access to ungulate habitat (sheep, caribou, and goats).

Our analyses identify conflicts between wind power developments and wildlife and habitat management protocols. While the M-KMA recognizes that habitat suitability will decline during periods of resource extraction, a fundamental difference with wind power is that the duration of the facilities' operation is apparently open-ended since the wind resource is renewable. In general, there appears to be no simple quantitative guideline establishing when disturbed habitat is to be restored for any extraction activity outside of recommendations for the re-establishment of wilderness characteristics within 75 years of the cessation of operations. Rather, habitat restoration is to proceed in an effective and timely fashion and seemingly relies on the fact that most extraction activities have a clear and relatively short 'life of project' schedule. Long-term habitat sustainability within the M-KMA considers human use and developments in four timescales (M-KWMP 2009*a*): short term (1–4 years), near term (5–20 years), medium (20–100 years), and long term (> 100 years). We contend that wind power developments, if allowed to proceed, will have long-term implications on habitat suitability and possibly the status of some wildlife species, in part due to the open-ended lifespan of wind power projects but also due to the slow recovery of alpine habitats following disturbance. We further contend that resource extraction activities with temporally indefinite footprints may erode the ability of the Muskwa-Kechika Advisory Board to respond if wildlife populations decline to critical numerical thresholds or to mitigate climate change that is expected to reduce the extent of alpine habitats (M-KWMP 2009*b*).

Direction from the Pre-tenure Plans for Oil and Gas Development in the Muskwa-Kechika Management Area (BCMSRM 2004) state targets of 97% (moose) to 98% (sheep) of moderately high and high capability winter habitat remaining undisturbed (as of publication of the Pre-tenure Plans information and direction were lacking to generate targets for caribou). We assume that our delineation of habitat for caribou, moose, and sheep approximates moderately high and high capability habitat, but includes growing season and winter habitat. Our analyses of IUP buffered footprints suggest that habitat disturbance will likely exceed targets for all three focal species in the Upper Halfway River Watershed. Analyses of wildlife viewsheds also suggest that over the four affected watersheds targets for undisturbed wildlife habitat will not be met.

Access roads in support of the IUPs are expected to be maintained and used year-round and will likely prevent access scheduling to avoid sensitive wildlife habitats at sensitive times of the year. Although some species have demonstrated the ability to habituate to roads (e.g., McLellan and Shackleton 1989*a*, 1989*b*), or in some cases to be attracted to road side vegetation or road-killed animals (Forman and Alexander 1998; Fahrig and Rytwinski 2009), the population level consequences of habitat use in the proximity of roads with respect to direct mortality (harvest, poaching, collisions with vehicles, and enhanced predation) generally remain unclear. For some species, roads have been demonstrated to act as population sinks (Mumme et al. 2000; Trombulak and Frissell 2000) or as the source of habitat or population fragmentation (Forman and Alexander 1998; Trombulak and Frissell 2000). Additionally, road access to high-elevation sites in conjunction with year-round road maintenance is expected to create predator access to habitats that ungulates traditionally use as an anti-predator strategy (Bergerud and Page 1987). For species like caribou, a single access point into high elevation winter range is sufficient to allow wolves access to much of the winter range as travel, once on the range, is relatively easy due to wind-swept conditions.

The general impacts of wind tower developments on wildlife species have been summarized by McCann (2010). Mortalities of birds and bats are well documented but determination of population level consequences generally remains elusive. Exclusive of raptors, general conclusions are that avian mortality due to wind power installations is not significant notwithstanding incomplete knowledge about staging areas, migratory flyways and population levels of specific species. Raptors and bats appear more at risk of population level consequences as both exhibit long lifespans and low reproductive rates. Raptors also occupy a high trophic level with resultant low abundance, and frequently use ridgelines to take advantage of thermal winds. Staging areas and migration habitat for migratory avian species is identified as a priority for management by the M-KWMP (2009*b*). Use of high elevation subalpine and alpine habitats is noted for many avian species including shore birds, raptors, and passerines during late summer and fall migration (M-KWMP 2009*b*). In particular, the eastern foothills of the Rocky Mountains are identified as a corridor for raptors and potentially for other migrants (Thomas et al. 2011). Vulnerability of bats to wind power installations appears greatest for migratory species and six species identified in mortality records of wind power installations elsewhere occur in British Columbia. The placement of wind tower facilities in pristine high elevation subalpine and alpine habitats that are limited in extent and important habitats for large fauna, avian migrators, and potentially migratory bat species appears to be unprecedented. Relevant guidance is lacking in the literature, although concern has been expressed by regulatory agencies (see McCann 2010).

Wilderness and Visual Quality

M-KMA's definition of wilderness incorporates ecological considerations, extensive tracts of land, and human perceptions of naturalness or wildness (M-KAB 2004). Ecological considerations focus on viable, self-sustaining plant and wildlife populations unimpaired by anthropogenic disturbances and functioning within the range of natural variation. Our approach to accounting for wilderness was through buffering (3.83 km) of existing anthropogenic disturbances and determining that area free of direct disturbances or associated zones of influence. Such an approach can only provide guidance as to what areas may remain ecologically pristine. Given the extensive movements made by large fauna and the ability of distant barriers to movement to affect local gene flow it is not possible to fully determine if local or distant anthropogenic activities have negligible consequences on floral and faunal population function. Additionally, the definition of extensive tracts of land (> 5,000 ha) is clearly within the realm of human perception and has little relationship to annual or multi-annual home range sizes of animals like grizzly bears and caribou.

Notwithstanding the vicissitudes of human perceptions of naturalness or wildness, we are best able to comment on wind power development and human perceptions of naturalness as it relates to wind tower viewsheds. We took a conservative approach in assessing impacts to visual quality and assumed that any visible tower would detract from a perception of naturalness. We justify this approach since the placement of wind towers on ridgelines (i.e., skyline developments) precludes opportunities to blend wind power projects into the landscape as per the general management themes noted above, wind towers are large, illuminated, non-static, and may produce visual anomalies such as shadow flicker and sunlight reflection. We estimate that 8.6% of the total wilderness within the M-KMA and 17% of the front ranges will be visually affected by existing IUPs. Consideration of visitor use patterns and the accessibility of wilderness to visitors, although beyond the scope of this report, should be additional factors weighing on the acceptability of the IUPs.

IMPLICATIONS

Ultimately, an assessment of the compatibility of current wind power permits with M-KMA values can not be determined without first establishing acceptable thresholds to ecological change and a formal cumulative effects analysis across all industrial and recreational activities that occur within the M-KMA. As noted in MKWMP (2009a) and the strategic land use plan implementation framework (Stuart Gale and Associates 2007), the determination of ecological impact thresholds for ecosystem processes and components is an important aspect of an ecological approach to management. In the absence of thresholds and monitoring to determine the state of the ecosystem, it would seem incumbent on managers to clearly articulate their attitude to risk and to manage within such bounds. Additionally, it should be incumbent on the wind power industry to deliver a sound monitoring framework to identify and quantify the impacts that wind power has on wildlife, habitat and wilderness and sound options for mitigation of identified impacts. Such commitments should be ingrained in any economic viability assessment of wind power projects.

Wind power development within the M-KMA has several unique aspects that are clearly incompatible with the other M-KMA values we assessed: ridge top developments; long linear developments, year-round access; the creation of predator access into sensitive prey habitats; indefinite temporal footprints; unknown consequences on many local wildlife species; known impacts on many local species but without population level understanding; slow site recovery under natural processes; little opportunity for application of landscape design to obscure tower installations; and an extensive visual footprint. The willingness of the general public to accept the impacts of wind power developments, in particular with respect to wilderness viewsheds, should be determined as the public is the final client.

LITERATURE CITED

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